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**Type-B Accident Investigation Report  
of the January 20, 1998, Electrical Accident  
at Casa Grande Substation, South of Phoenix, Arizona**



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**Western Area Power Administration  
U.S. Department of Energy**

This report is an independent product of the Type-B Accident Investigation Board appointed by Michael S.Cowan, Chief Program Officer, Western Area Power Administration.

The Board was appointed to perform an investigation of this accident and to prepare a report in accordance with DOE Order 225.1A, *Accident Investigations*.

The discussion of facts, as determined by the Board, and the views expressed in this report do not assume and are not intended to establish the existence of any duty at law on the part of the U.S. Government, its employees or agents, contractors, their employees or agents, or subcontractors at any tier, or any other party.

This report neither determines nor implies liability.

FEB 12 1998

On January 20, 1998, I established a Type-B Accident Investigation Board to investigate the January 20, 1998, electrical accident at Casa Grande Substation south of Phoenix, Arizona. The Board's responsibilities have been completed with respect to this investigation. The analysis, identification of contributing and root causes, and judgments of need reached during the investigation were performed in accordance with DOE Order 225.1A, *Accident Investigations*.

I accept the findings of the Board and authorize the release of this report for general distribution.

A handwritten signature in dark ink, appearing to read "MS Cowan", written over a horizontal line.

Michael S. Cowan, Chief Program  
Officer

# Table of Contents

|  |     |
|--|-----|
| Table of Contents  | i   |
| Exhibits, Figures and Tables                                       | ii  |
| Acronyms and Initialisms   | iii |
| Executive Summary  | iv  |
| <br>   |     |
| 1.0 Introduction   | 1   |
| 1.1 Background   | 1   |
| 1.2 Accident Site Description                                      | 1   |
| 1.3 Scope, Conduct, and Methodology                                | 1   |
| 2.0 Facts and Analysis   | 3   |
| 2.1 Accident Description and Chronology                            | 3   |
| 2.1.1 Accident Description   | 3   |
| 2.1.2 Chronology of Events   | 9   |
| 2.1.3 Emergency Response and Investigative Readiness               | 10  |
| 2.2 Hazards, Controls and Management Systems                       | 10  |
| 2.2.1 Construction Safety  | 10  |
| 2.2.2 Personnel Qualifications and Experience                      | 11  |
| 2.2.3 Western's Policies and Procedures                            | 12  |
| 2.2.4 Human Factors and Training                                   | 12  |
| 2.5 Management Systems   | 13  |
| 2.3 Barrier Analysis   | 14  |
| 2.4 Causal Factors   | 15  |
| 3.0 Conclusions and Judgments of Need                              | 18  |
| 4.0 Board Signatures   | 19  |
| 5.0 Board Members, Advisors and Staff                              | 20  |
| <br>   |     |
| Appendix A — Appointment Memorandum                                | 21  |
| Appendix B — Switching Diagram and 12.47-kV Area Plan View         | 22  |
| Appendix C — Clearance, Switching Program, and Special Work Permit | 23  |

# Exhibits, Figures and Tables

Figure 1      Chronology of Events Chart

Exhibit A      Views of Work Site and Equipment

Exhibit B      View of Burn Marks on 12.47-kV Transfer Bus

Exhibit C      View of Prefabricating Isolating Barriers

Exhibit D      View of Burn Mark on 12.47-kV Steel Structure

Exhibit E      View of Burn Mark on Bottom of Steel Beam

Exhibit F      View of Burn Mark on Center Phase Transfer Bus Bolts

Exhibit G      View of Burn Mark on Victim's Lanyard

Exhibit H      View of Burn Marks on Victim's Right Boot

Exhibit I      View of Burn Marks on Victim's Pants

Table 2.1      Performance of Barriers

Table 2.2      Causal Factors Analysis

Table 3.1      Conclusions and Judgments of Need

# Acronyms and Initialisms

|        |   |
|--------|---|
| APS    | Arizona Public Service Company                |
| CO     | Contracting Officer                           |
| COR    | Contracting Officer's Representative          |
| CPO    | Chief Program Office(r)                       |
| CSO    | Corporate Services Office                     |
| DOE    | Department of Energy                          |
| DSWR   | Desert Southwest Region                       |
| EMT    | Emergency Medical Technician                  |
| HLO    | Hot Line Order                                |
| JHA    | Job Hazard Analysis                           |
| OSHA   | Occupational Safety and Health Administration |
| PSOM   | Power System Operations Manual                |
| PSSM   | Power System Safety Manual                    |
| RMR    | Rocky Mountain Region                         |
| UGPR U | Upper Great Plains Region                     |

# Executive Summary

## Introduction

On January 20, 1998, at 10:07 a.m (MST), an Apprentice Lineman employed by High Power, Inc., a Western contractor, was seriously injured when he contacted an energized 12.47 kilovolt (kV) bus at the Casa Grande Substation, south of Phoenix. The Victim was transported by air ambulance to the Maricopa Medical Center in Phoenix, AZ.

On January 20, Michael S. Cowan, Western's Chief Program Officer (CPO), appointed a Type-B Accident Review Board (Appendix A), to investigate the accident in accordance with Department of Energy (DOE) Order 225.1A, *Accident Investigations*.

The Board began its investigation on January 21, 1998, and submitted its findings to the appointing official on February 12, 1998.

## Accident Description

The accident occurred at the Casa Grande Substation, which is located on the west edge of the town of Casa Grande. The weather was clear and dry and the work site was uncluttered.

Prior to the accident, Western's maintenance personnel had removed most of the 115-kV feed as well as the 12.47-kV feed to the 12.47-kV main bus, and built a temporary shoo-fly to feed the 12.47-kV main bus loads. This work facilitated access to the bus structure from the south to allow installation of isolation barriers and other construction work. The isolation barriers, which were a requirement in the specifications, were to be fabricated from plywood and attached to the south side and west end of the 12.47-kV bus structure. The intent of the barriers was to prevent equipment from coming in contact with the 12.47-kV main bus. Western employees determined at an onsite meeting that pieces of rigid-bus protruding towards the south would be in the way of the barriers. A decision was made to remove these while the main bus was under clearance for installation of the barriers.

The morning of the accident a clearance was obtained on the 12.47-kV main bus. The Electrical District loads were served from a 12.47-kV tie from APS back through the 12.47-kV transfer bus. No Hot Line Order was requested. The points of protection of this clearance were explained to the Contractor Superintendent when the Special Work Permit was issued.

Following completion of a verbal job hazard analysis, an Apprentice Lineman (Victim) was assigned to assist with removal of three rigid-bus stub jumpers from the main bus. He used a ladder to access the top of the steel structure. He then positioned himself directly above the transfer bus in an area that was outside the safe work area of the Clearance. His right foot contacted the energized transfer bus. The APS tieline, which was feeding the loads on the transfer bus, tripped out upon the initial contact. The line reclosed approximately 5 seconds later. The Victim, suspended in his body harness and in contact with the transfer bus, experienced a second electric shock. The line tripped-out the second time, the recloser locked-out, and the line remained deenergized. The Victim pulled himself clear of the bus and was safely lowered to the ground by the Contractor crew.



Western employees telephoned 911 to request emergency assistance. The victim was quickly transported to Maricopa County Hospital in Phoenix.

## **Root and Contributing Causes**

The Board determined that the root cause of the accident was that the Victim moved outside the safe work area as defined by the Clearance and Special Work Permit issued by Western. The Board also identified eight contributing causes that could have eliminated or lessened the severity of the accident, if they had been adequately addressed.

## **Conclusions**

Western has adequate policies and procedures in place to avert accidents of this type. The training provided is sufficient to allow implementation of these policies and procedures. However, the procedures associated with the Special Work Permits, JHAs, and HLOs were not rigorously followed.

The Contractor's plan for working near energized equipment was not finalized in writing. It overlooked the need to work at the minimum safe working distance to install the barriers and remove the bus pieces. The appropriate request for a HLO was not made by the Contractor. The Contractor's employees were aware of the clearance limits, placed personal protective grounds on the main bus, yet treated the transfer bus as deenergized and grounded.

The Board developed five judgments of need from the conclusions and causal factors. These are as follows:

- Western needs to ensure that all parties rigorously follow the Special Work Permit and JHA procedures.
- Management needs to ensure that procedures for specific sequences of work adjacent to energized equipment are submitted by the contractor and reviewed by Western.
- Management needs to ensure that the contractor's plan identifies work near energized equipment and includes appropriate requests for HLOs.
- Management needs to continually communicate to all involved employees the need to treat ungrounded equipment as energized. This should be a topic of discussion at all management/contractor safety related meetings.
- Management needs to ensure that all Western and Contractor employees understand that they are responsible for their own safety.

**Type-B Accident Investigation Report  
of the January 20, 1998, Electrical Accident at  
the Casa Grande Substation, South of Phoenix, Arizona.**

## **1.0 Introduction**

### **1.1 Background**

On January 20, 1998, at 10:07 a.m (MST), an apprentice lineman employed by High Power, Inc., a Western contractor, was seriously injured when he contacted an energized 12.47 kilovolt (kV) bus at the Casa Grande Substation, south of Phoenix. He suffered burns to his left arm, chest, right thigh, and right foot. The Victim was treated at the scene by emergency medical technicians and transported by air ambulance to the Maricopa Medical Center in Phoenix, AZ.

On January 20, Michael S. Cowan, Western's Chief Program Officer (CPO), appointed a Type-B Accident Review Board (Appendix A), to investigate the accident in accordance with Department of Energy (DOE) Order 225.1A, *Accident Investigations*.

The Board began its investigation on January 21, 1998, and submitted its findings to the appointing official on February 12, 1998.

### **1.2 Accident Site Description**

The Casa Grande Substation is located on the west edge of the town of Casa Grande, approximately 55 miles southeast of the Desert Southwest Regional (DSWR) Office in Phoenix. The site is located approximately 1/2 mile north of State Highway 84 on Thornton Road. The weather at the time of the accident was clear and dry.

The work site on the day of the accident was uncluttered. Prior to the accident, Western's maintenance personnel had removed most of the 115-kV feed as well as the 12.47-kV feed to the 12.47-kV main bus, and built a temporary shoo-fly to feed the 12.47-kV main bus loads. This work facilitated access to the bus structure from the south to allow installation of isolation barriers and other construction work.

### **1.3 Scope, Conduct, and Methodology**

The purpose of the investigation was to determine the causes of the accident, including deficiencies, if any, in Western's construction and contractor management systems, and to help Western promote safety and reduce the potential for similar accidents.

The Board evaluated the Western Construction Office priorities, contractor/government relations and interactions, safety precautions, operational controls and management controls in place at the time of the accident. Interviews were conducted with witnesses and other appropriate Contractor and Federal personnel.

The Board conducted an extensive review of Western's switching documents, substation and dispatch logs, dispatcher voice recordings, Construction Specifications, substation drawings, and both Western's and Contractor's safety practices and training records.

The Board used the following accident investigation methods:

- Site visits and interviews
- Events and Causal Factors Analysis
- Barrier Analysis

## **2.0 Facts and Analysis**

### **2.1 Accident Description and Chronology**

#### **2.1.1 Accident Description**

The morning of the accident, following completion of a verbal job hazard analysis (JHA), the Apprentice Lineman (Victim) was assigned to assist with removal of three sections of rigid-bus stub jumpers from the main bus. He used a ladder to access the top of the steel structure. He then positioned himself directly above the transfer bus in an area that was outside the safe work area of the Clearance (Appendixes B and C). At this point his right foot contacted the energized transfer bus. The APS tieline, which was feeding the loads on the transfer bus, tripped out upon the initial contact. The line reclosed approximately 5 seconds later. The Victim, suspended in his body harness and contacting the transfer bus, experienced a second electric shock. The line tripped-out the second time, the recloser locked-out, and the line remained deenergized. The Victim pulled himself clear of the bus and was safely lowered to the ground by the contractor crew (See Exhibits A-I).

#### **2.1.2 Chronology of Events**

See Figure 1 for a summary of significant events

## **EXHIBIT A**



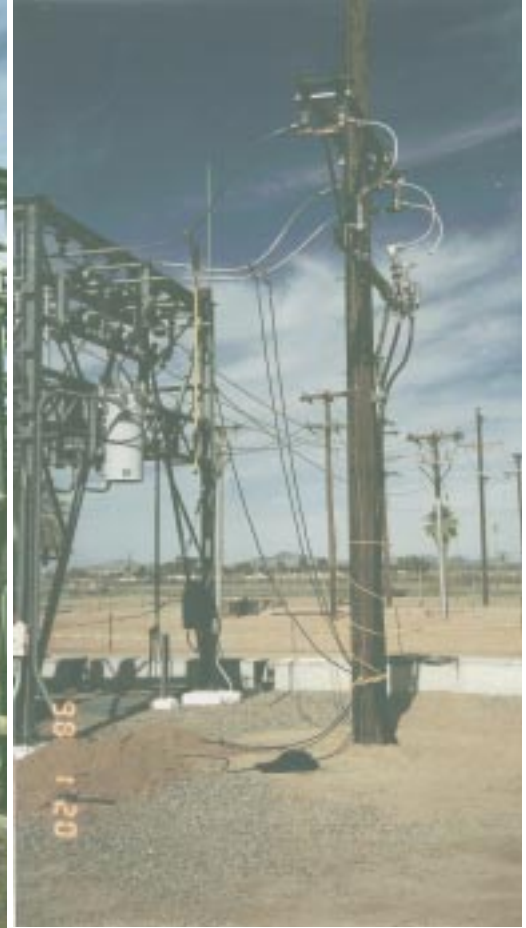
### **NORTH VIEW**

The grounding transformer KZ3A and jumpers scheduled to be removed to place an isolation barrier on the west-end. The picture also shows Disc. SW. 1421 open, locked and tagged



### **BAY Z1 NORTH VIEW**

Showing the location where work was to be performed, which included removal of three pieces of stub bus

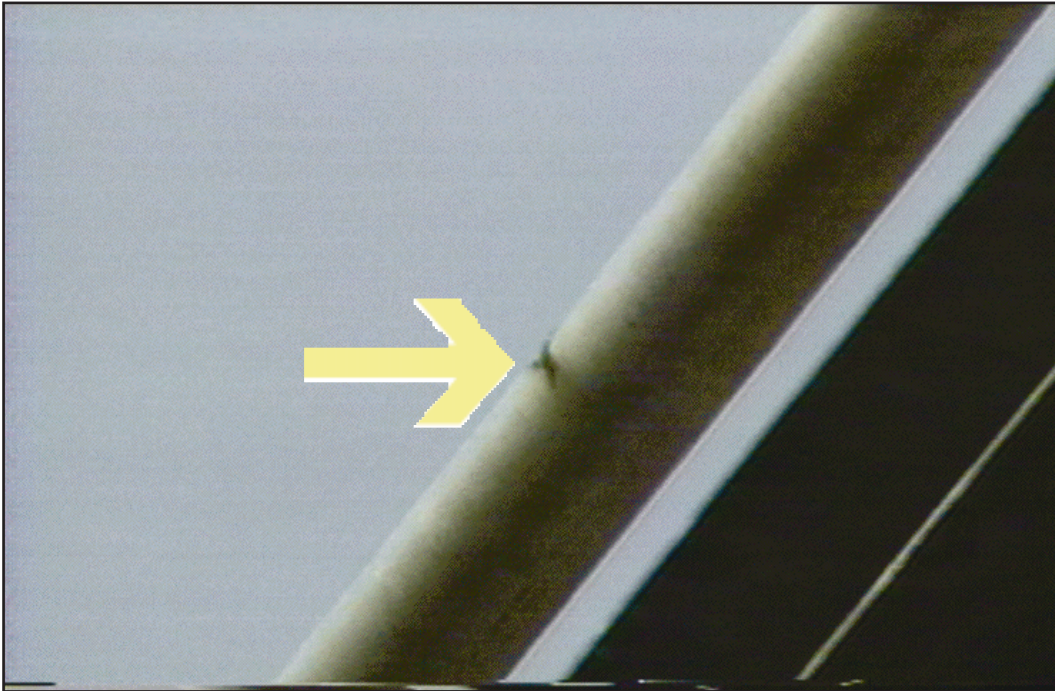


### **NORTH VIEW**

Temporary feed located east of the 12.47-kV bus structure. The picture also shows the location of personal protective grounds on the east side of the main bus.



## **EXHIBIT B**



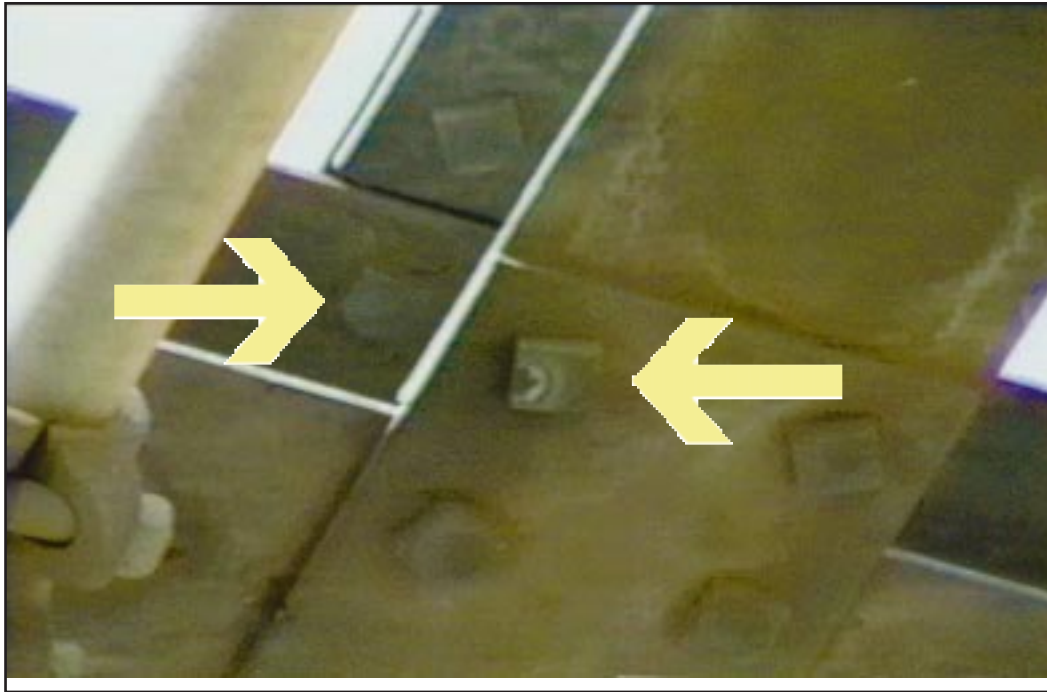
Electrical burn mark on south phase of 12.47-kV  
transfer bus

## **EXHIBIT C**



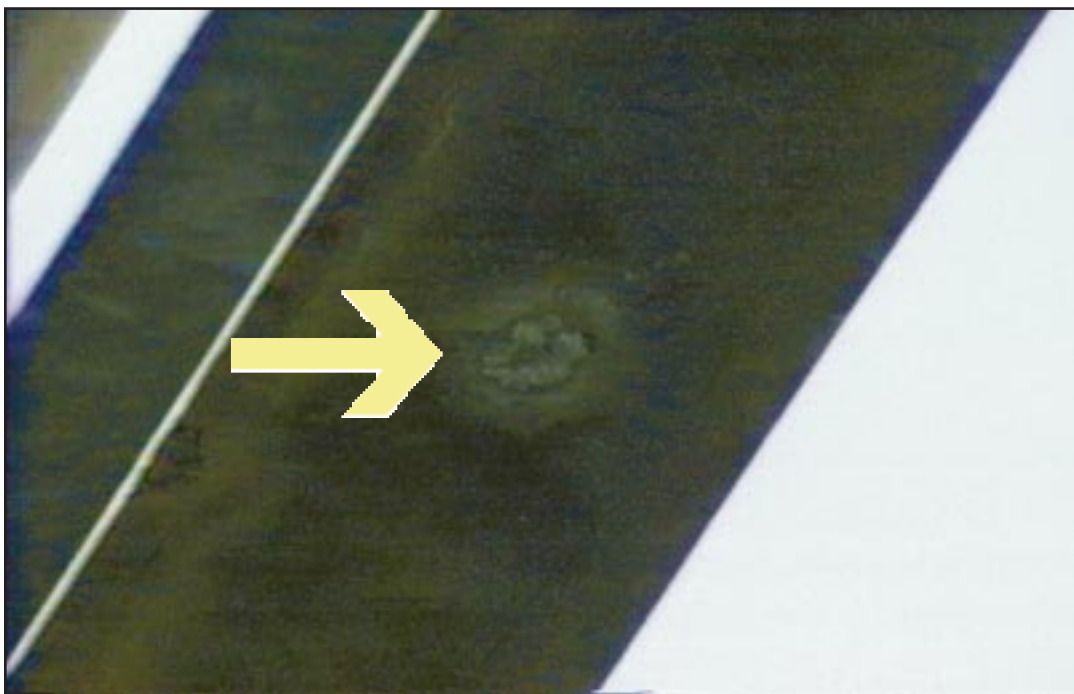
View of the prefabricated isolating barriers to be  
placed along the south and west sides of the  
12.47-kV bus structure

## **EXHIBIT D**



View showing a burn mark on the bottom of the bolt head located on the 12.47-kV steel structure

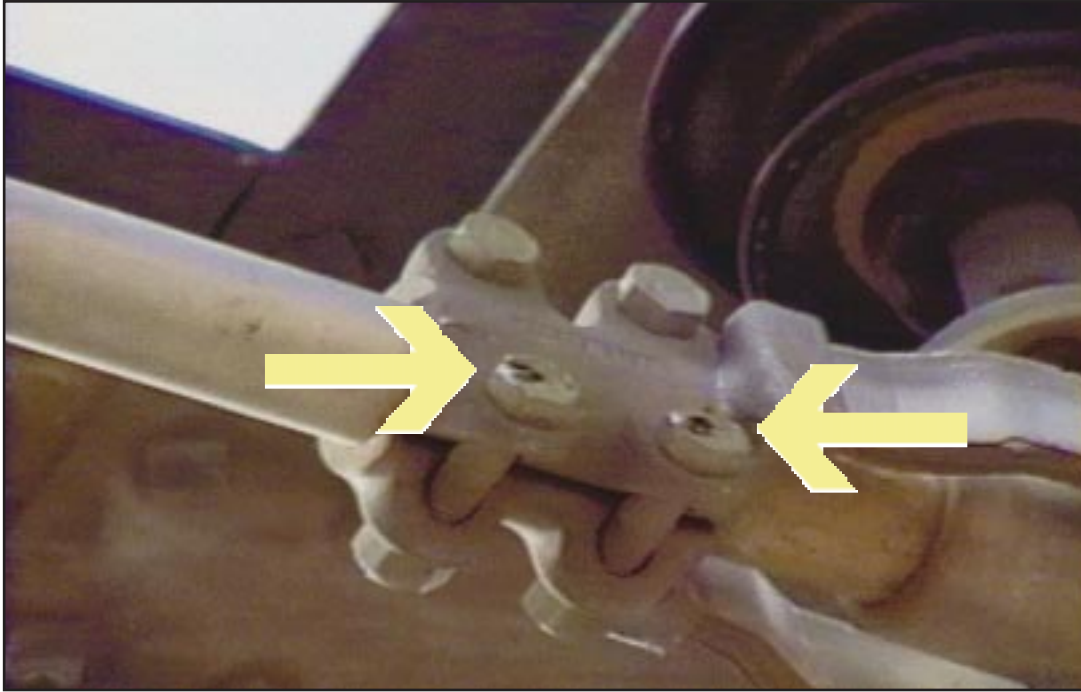
## **EXHIBIT E**



View of a burn mark located on the bottom section of the steel beam



## **EXHIBIT F**



View of burn marks on the bolts located on the  
center phase transfer bus

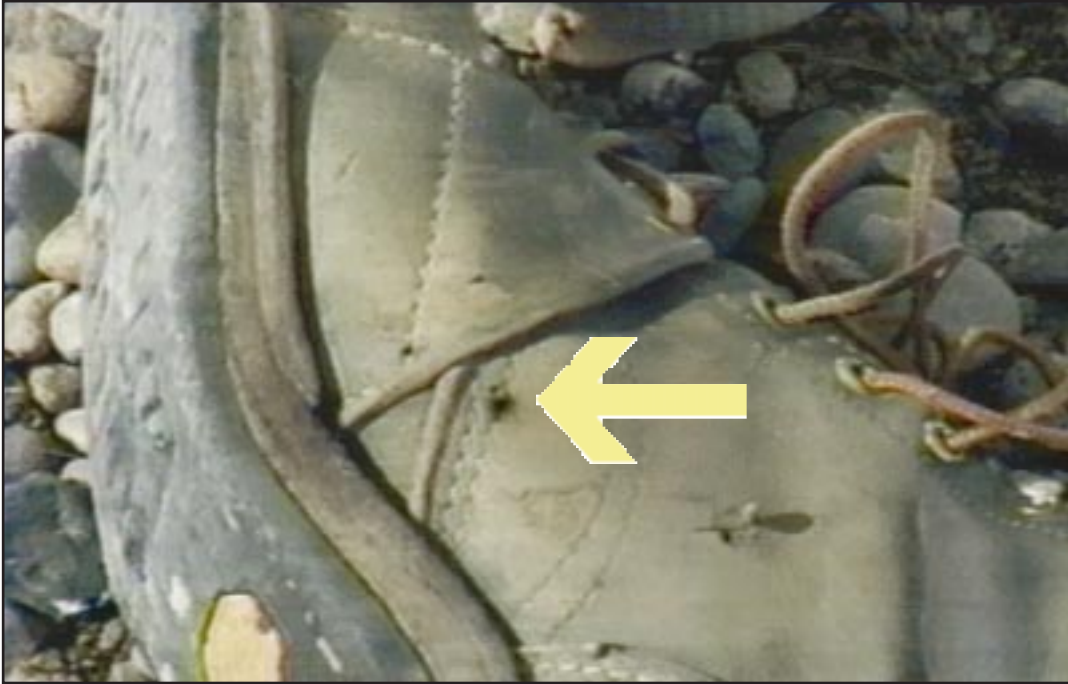
## **EXHIBIT G**



View of electrical burn mark located on the victim's  
lanyard



## **EXHIBIT H**



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View of the victim's right boot showing the electrical  
burns

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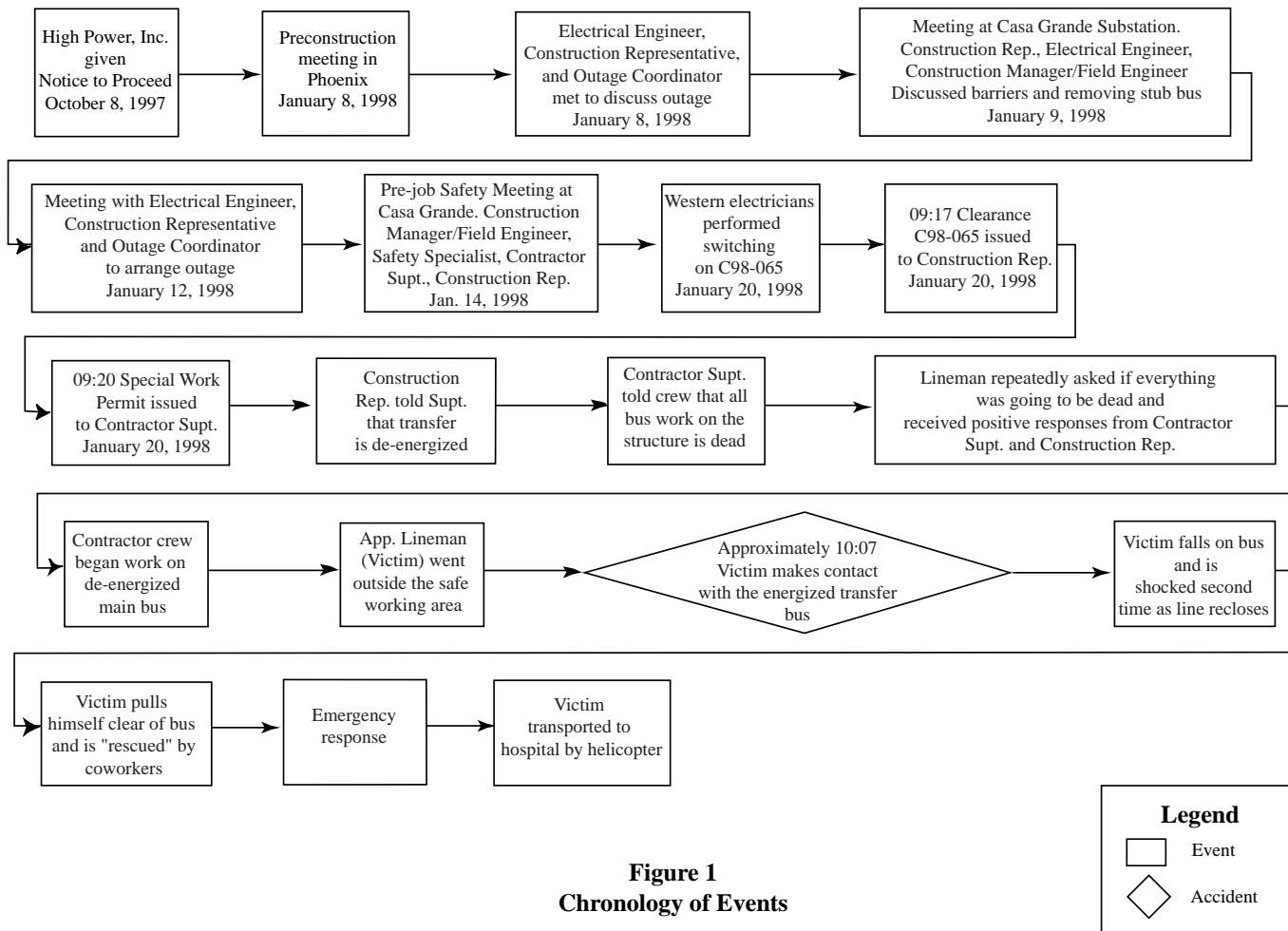
## **EXHIBIT I**



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View showing burn marks on the victim's pants

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**Figure 1**  
**Chronology of Events**

### **2.1.3 Emergency Response and Investigative Readiness**

Following the accident, when the crew was sure that the Victim was clear of the transfer bus, they safely lowered the Victim to the ground. The crew began first aid procedures by keeping the Victim calm, warm and comfortable until the EMTs arrived. Western employees immediately called 911 for medical assistance. Western's Dispatch Office and other appropriate personnel were promptly notified of the accident. Western and Contractor personnel showed immediate concern for the welfare of the Victim and their own safety and acted in an effective and timely manner in response to the accident.

DSWR Safety Office and Western's Construction Office personnel reviewed and secured the accident site, obtained site photographs, and collected information relative to the accident, which was presented to the Investigation Board.

The Board found that the Contractor had correctly developed and submitted provisions for first-aid and medical care, as required by construction specifications. Emergency notifications were issued in a timely manner in accordance with applicable DOE and Western Orders.

## **2.2 Hazards, Controls and Management Systems**

### **2.2.1 Construction Safety**

#### Construction Specifications

Western's construction specifications provide for management controls to prevent accidents. Key provisions relative to this accident are requirements for:

- Contractor submittal of a safety program prior to beginning work, including a requirement for a written plan for any proposed work adjacent to energized equipment to ensure adequate activity hazard analysis and provide for protective measures
- Joint Western and Contractor safety meetings, including a pre-construction safety meeting, management safety awareness meetings, and periodic joint safety meetings
- Contractor's submittal of the Superintendent's resume and qualifications proving at least 3 years experience as a superintendent or foreman and demonstrated knowledge of OSHA standards
- Maintaining the minimum electrical clearance distance of 10 feet for voltages of 50 kV or below, as stated in OSHA 1926.550, unless provided written approval by the COR to use the less stringent electrical clearance distance established in OSHA 1926.950.
- Contractor request of clearances, hot line orders and issuance of special work permits by Western to the contractor
- Training and knowledge of all contractor employees

### Pre-construction Meeting

Western routinely holds a pre-construction meeting with both Western and contractor personnel prior to beginning work under a construction contract. The pre-construction meeting associated with the Casa Grande Substation, Stage 02, Contract DE-AC65-97WG30340 was scheduled with High Power, Inc., by letter dated December 22, 1997. A copy of the meeting agenda was enclosed. This meeting was scheduled for 2 p.m. on January 8, 1998, at Western's DSWR office in Phoenix.

Pre-construction meetings are typically administrative in nature and the agenda for this meeting followed this format. Specific safety topics were included.

The meeting was held as scheduled and attended by the owner of High Power, Inc., the Contractor Superintendent, and 10 Western employees. The meeting generally followed the agenda and specifically referenced the necessity of a pre-construction safety meeting and weekly toolbox meetings. The Contractor Superintendent's responsibility for carrying out the Contractor's safety and health program was addressed.

### Pre-Job Safety Meeting

Western routinely holds a pre-job safety meeting with both Western and contractor personnel prior to beginning work. The meeting for this contract was held onsite at the Casa Grande Substation January 14, 1998. The minutes of this meeting indicate attendance by the Contractor Superintendent from High Power, Inc., Western's Construction Manager (Acting Field Engineer), Western's Construction Representative (Inspector) and a Western Safety Specialist.

This meeting, according to the minutes, was comprehensive and included some issues pertinent to the specific job. Placement of plywood barricades (Exhibit C) on portions of the south and west sides of the bus structure was discussed. Discussion items included working in close proximity to energized facilities, the need for a JHA, maintaining safe working distances, hot line orders (HLOs), and proper grounding procedures, including documentation of locations of grounds on the Special Work Permit (Appendix C).

## **2.2.2 Personnel Qualifications and Experience**

### Construction Representative

The Construction Representative assigned to Casa Grande Stage 02 at the time of the accident has over 30 years of job experience and has been a Western employee since 1979. During that period he worked with contractors in several regions of Western and has become known as one of the most knowledgeable inspectors. He was described by one individual as the inspector with the "most experience" in Western. This level of respect and trust was confirmed in the interviews conducted by the Board. The Construction Representative received two significant Western awards in 1997 for his work in substation construction.

The Construction Representative worked with High Power, Inc. on at least five separate jobs and with the High Power Construction Superintendent assigned to Casa Grande Stage 02 on several of those jobs. This was considered a plus by Western's Construction Office personnel since communications between the two were considered to be open and frank. The Construction Representative had significant and recent experience as a switchman. He held a current Switchman Certificate from DSWR dated 11-18-97, and was certified to switch in the UGPR in 1997.

### Contractor's Superintendent

The Contractor's Superintendent has 15 years experience in the high-voltage construction industry, including 10 years with High Power, Inc.

He met the Specification experience requirements of 3 years as a superintendent or foreman in high-voltage substation construction. He also had the requisite OSHA knowledge and had a properly-submitted resume.

Western employees from the three construction offices are familiar with the Construction Superintendent and his work. In interviews they spoke highly of his abilities, experience, and his supportive attitude toward both the Contractor's and Western's Safety Programs.

### Western's Employees

Western's employees involved in the work on Casa Grande Stage 02 included construction managers, engineers, craftsmen, and dispatchers. Without exception, these employees had adequate experience and training to perform the work involved.

### Contractor's Employees

The Contractor's workforce, other than the Contractor Superintendent, consisted of two journeyman linemen and two apprentices. The journeymen had many years of high-voltage construction experience. The Victim graduated from a lineman training program and had prior experience with a South Dakota electrical cooperative. These employees were trained in first-aid and CPR.

## **2.2.3 Western's Policies and Procedures**

### Western's Accident Investigation Program

Western investigates accidents and near-miss incidents to determine root causes and prepare judgments of need. The judgments of need, which are widely circulated, are intended to prevent future occurrences of similar incidents.

### Western's Power System Operations Manual, Chapter 1, "Power System Switching Procedure"

This document establishes coordinated and consistent switching procedures for the safe and reliable operation and maintenance of those facilities of the Federal power system for which Western is responsible. These procedures include clearances, hot line orders, special conditions, danger tags, general switching, and special work permits.

## **2.2.4 Human Factors and Training**

The Board met with personnel involved with the Casa Grande Construction Project and found no evidence of animosity or ill-feeling among themselves or towards Western or High Power, Inc. In fact, the overall attitude of those involved was positive and supportive of Western's and High Power, Inc's construction activities and safety programs. The cooperation and working relationship between Contractor and Western personnel were found to be satisfactory and positive. All individuals stated that they were not pressured to complete the work in any way other than in a safe manner.

The Board found no evidence of physical or mental impairment among the Contractor or Western personnel.

A review of training records showed that contractor crew members and Western personnel had more than adequate training and experience to perform the work safely.

The Board found that weather conditions at the time of the accident were not adverse and had no affect on the accident.

### **2.2.5 Management Systems**

#### Western's Occupational Safety and Security Program

This program outlines most aspects of planning and directing the safety program for all activities including the construction, operation, and maintenance of high-voltage transmission lines, substations, and related facilities in a large geographical area. The safety program includes a wide variety of functions directed at eliminating undesirable operating conditions and minimizing hazards.

Construction is generally performed by contract employees, while operation and maintenance is performed by Western employees.

The Program allows for comments and input in the development of safety policies and provides guidelines to field managers and supervisors in the formulation of local safety policy. It provides general safety oversight and direction at all operational levels in the field offices for development of operational and work procedures.

Specific provisions of the safety guidelines:

- Allow review of designs and specifications for new facilities to ensure compliance with existing safety standards
- Allow review of construction contractor safety programs and work procedures to ensure compliance with specifications and safety requirements
- Require participation of a safety adviser in meetings between contractor and Western managers
- Promote working with managers and administrative staff to evaluate employee skills and safety training needs
- Promote participation of operation and maintenance staff in supervisory safety meetings
- Provide technical guidelines to assist supervisor and managers in development of specialized safety training
- Require coordination and oversight of complete safety audit system



- Provides technical guidance to committees and meetings
- Requires investigation of accidents resulting in personal injury or property damage
- Requires development and implementation of safety awareness programs

## 2.3 Barrier Analysis

A barrier is defined as anything that is used to control, prevent, or impede a process and is intended to protect a person or object from hazards. The Board conducted a barrier analysis that identified safety, administrative, and management barriers that failed. Successful performance of any of these barriers would have prevented or mitigated the severity of the accident. The barriers that failed are listed in Table 2.1

**Table 2.1 Performance of Barriers**

| <b>Barriers</b>   | <b>Purpose</b>   | <b>Performance</b>  |
|---|--|---|
| Job Preplanning   | To determine the scope of work and to inform involved personnel of that scope.   | Barrier failed because the planning was inadequate and not all of the involved personnel understood all parts of the scope of work.   |
| Contractor Safety Program   | To comply with Federal regulations and establish contractor safe working procedures and policies.  | Barrier failed because the Contractor Victim did not follow the safe working policies and procedures established in the Safety Program.   |
| Power System Operations Manual (PSOM), Chapter 1 Switching Procedure        | To establish coordinated and consistent switching procedures for the safe and reliable operation and maintenance of those facilities of the Federal Power System for which the Western Area Power Administration is responsible. | The barrier failed because the personnel involved failed to ensure that the clearance limits stated on the Special Work Permit were adequate for the work performed. Personnel also failed to recognize the need for a HLO. |
| Western's specifications paragraph on electrical clearance distances, 1.5.9 | Requires written authorization from the COR for contractor forces to work at the less stringent electrical clearance distances established by OSHA.  | The personnel involved failed to recognize the need to request this written approval from the COR.  |

|                     |   |   |
|---------------------|---|---|
| Job Hazard Analysis | To identify all potential hazards and develop work procedures to mitigate those hazards.                        | The barrier failed because it did not adequately identify the potential hazards.  |
| Training            | To ensure Western and contractor employees are well versed in safe work procedures and policies.                | The barrier failed because employees did not recognize the inadequacy of the defined safe working area.   |
| Experience          | To utilize the experience of Western and Contractor personnel to perform specified tasks safely and efficiently | The barrier failed because both Western and Contractor personnel exhibited so much trust in each other's experience that simple but vital assertions were not questioned. |

## 2.4 Causal Factors

The root cause of the accident was that the Victim moved outside the safe work area as defined by the Clearance and Special Work Permit issued by Western (Appendix C).

The Board also identified numerous contributing causes. Contributing causes are defined as those issues that increase the likelihood or the severity of the accident without individually causing the accident. Contributing causes are important enough to be recognized as requiring corrective action. The causal factors are identified in Table 2.2.



**Table 2.2 Causal Factors Analysis**

| <b>Root Cause</b>   | <b>Discussion</b>  |
|---|--|
| Victim Leaving Safe Work Area   | The Victim moved from an area that was protected by the Clearance and personal protective grounds to an area that was not protected in any way. This area (transfer bus) was in fact energized, which was not recognized by any of the workers or the Construction Representative. Even so, the Victim and the other linemen were aware that no grounds had been paced on the transfer bus. The owner of the construction company had a slogan, “If it isn’t grounded, it isn’t dead.” This appeared on all trucks as bumper stickers and was continuously reinforced in meetings. This basic principle was ignored by the Victim. |
| <b>Contributing Causes</b>  | <b>Discussion</b>  |
| Western’s Construction Representative stated that the 12.47 kV transfer bus was deenergized.  | The Board found no definitive reason as to why the Construction Representative would believe the transfer bus was deenergized. The Clearance was clearly for the main bus only. He participated in meetings with the Outage Coordinator where a discussion was held about feeding the load through the transfer bus. Western’s Construction Specifications for Casa Grande Stage 02 clearly state that concurrent outages of both buses are not possible.  |
| Contractor’s Superintendent reported to the linemen that the entire structure was deenergized | The Contractor’s Superintendent accepted without question the Construction Representative’s statement that the transfer bus was deenergized. He repeated this multiple times to his crew. He signed the Special Work Permit, which clearly stated the points of protection for the main bus and “walked those points” with the Construction Representative. He, by virtue of his position, knew or should have known, of the specification requirement that limits bus outages to one bus at a time. This knowledge should have corrected the erroneous idea that the bus was deenergized.   |
| Verbal JHA  | The Contractor’s verbal JHA provided discussion regarding points of protection for the main bus and placement of personal protective grounds. However, the participants did not identify the hazards associated with ungrounded equipment that included, but was not limited to, the grounding transformer KZ3A and the 12.47 kV transfer bus, nor did the JHA provide for protective measures to mitigate the hazards.  |
| Inadequate Review of the Special Work Permit  | Involved personnel did not review the Special Work Permit to ensure that the Clearance limits were adequate for the work planned. The Special Work Permit procedures had become a routine mechanical function.   |

|   |   |
|---|---|
| Inadequate planning   | <p>Pre-job planning, activity hazard analysis, and protective measures were inadequate because the Contractor did not develop a written plan and submit it to Western for review and comment. The plan to remove the rigid-bus stub jumpers from the main bus was inadequate. The Contractor did not obtain written approval from the COR to work at the less stringent electrical clearance distances established by OSHA 1926.950. Western's Specifications require the Contractor to maintain a minimum approach distance of 10 feet for voltages of 50 kV and below.</p>  |
| Lack of a Hot Line Order  | <p>Involved personnel, both Western's and the Contractor's, failed to recognize that a HLO would not have directly prevented the accident, but would have reduced the severity. A HLO would, possibly, have alerted the workmen to the fact that the bus was energized.</p> <p>Western's Construction Specifications and the PSOM, Chapter 1, are clear and specific on the procedures for obtaining a HLO.</p> <p>One Western employee stated that HLOs are not usually obtained on buses. In this case the bus was fed by a 12.47 kV line protected by a circuit breaker that was controlled by a single-shot recloser. A HLO could have been obtained.</p> |
| Workers did not take responsibility for their own safety  | <p>The Contractor's workers did not take total responsibility for their own safety. Instead they relied on verbal assurances, based on mutual trust, that devices were deenergized. They did not critically review the points of protection listed in the Special Work Permit, nor did they review the placement of personal protective grounds based on their understanding that the transfer bus and the grounding transformer KZ3A were deenergized.</p>   |
| Trust between Contractor's Superintendent and Western's Construction Representative resulted in a non-questioning attitude. | <p>Western's Construction Representative and the Contractor's Superintendent developed significant trust and respect for each other, often working together on various construction jobs. This relationship resulted in a non-questioning attitude between both individuals. For example, when Western's Construction Representative told the Contractor's Superintendent that the whole bus structure was deenergized, he accepted this without question rather than verifying its condition.</p>  |

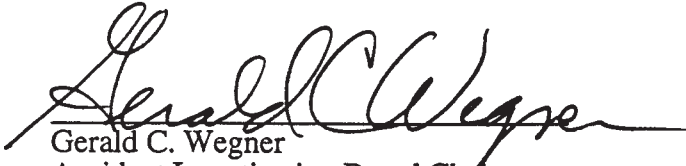
## 3.0 Conclusions and Judgments of Need

Conclusions are a synopsis of facts and analytical results that the Board considers especially significant. Judgments of need are management controls and safety measures believed necessary to prevent or mitigate the probability of recurrence. They flow from the conclusions and causal factors and are directed at guiding managers in developing followup actions.

**Table 3.1 Conclusions and Judgments of Need**

| Conclusions  | Judgments of Need   |
|--|---|
| The Special Work Permit and the JHA procedures failed to prevent the accident because they were not properly executed.   | Western needs to ensure that all parties rigorously follow the Special Work Permit and JHA procedures.  |
| The Contractor's safety program did not include written procedures for working near energized equipment. As a result of onsite impromptu planning, Western and the contractor failed to recognize that the minimum electrical safe working distance required by Western Specifications would have to be violated in order to perform the work. | Management needs to ensure that procedures for specific sequences of work adjacent to energized equipment are submitted by the contractor and reviewed by Western.  |
| Western's Specifications and PSOM, Chapter 1, require a HLO when working on or near energized equipment. The planned work was near energized equipment, however, the need for a HLO was not recognized.  | Management needs to ensure that the contractor's plan identifies work near energized equipment and includes appropriate requests for HLOs.  |
| The Contractor employees and Western's Construction Representative erroneously believed that the entire 12.47-kV bus structure was deenergized. They treated the whole structure as if it were grounded, when in reality, only the main bus was grounded.  | Management needs to continually communicate to all involved employees the need to treat ungrounded equipment as energized. This should be a topic of discussion at all management/contractor safety related meetings. |
| The workmen did not take responsibility for their own safety. They relied on others to ensure that the entire 12.47-kV bus structure was a safe work area.   | Management needs to ensure that all Western and Contractor employees understand that they are responsible for their own safety.   |

## 4.0 Board Signatures



Gerald C. Wegner  
Accident Investigation Board Chairperson  
Western Area Power Administration  
Billings, Montana

Date: 2-12-98



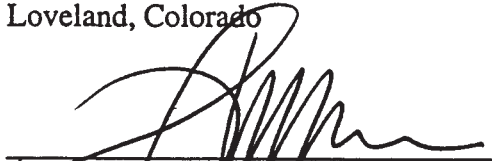
Patrick M. Doak  
Accident Investigation Board Member  
Western Area Power Administration  
Huron, South Dakota

Date: 2/12/98



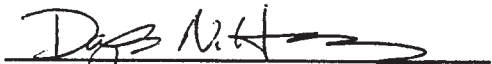
Troy E. Henry  
Accident Investigation Board Member  
Western Area Power Administration  
Loveland, Colorado

Date: 2/12/98



Lazaro (Larry) M. Romero  
Accident Investigation Board Member  
Western Area Power Administration  
Golden, Colorado

Date: 2/13/98



Douglas N. Harness  
Legal Advisor  
Western Area Power Administration  
Golden, Colorado

Date: 2/12/98

## 5.0 Board Members, Advisors and Staff

|                      |  |
|----------------------|--|
| Chairperson          | Gerald C. Wegner, Western, UGPR                  |
| Member               | Patrick M. Doak, Western, UGPR                   |
| Member               | Troy E. Henry, Western, RMR                      |
| Member               | Lazaro ( Larry ) M. Romero, Western CSO          |
| Member/Legal Advisor | Douglas N. Harness, Western CSO                  |
| Technical Writer     | Gerry Himes, Remtech Services, Inc., Western CSO |

## **APPENDIX A**

---

### **Appointment of Type-B Accident Investigation Board**

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# memorandum

Western Area Power Administration

DATE: JAN 21 1998

REPLY TO  
ATTN OF: A3000

SUBJECT: Accident Review Board--Casa Grande Substation Accident, January 20, 1998

TO: D. Vernon, Office of Security Evaluation, EH-21  
G. Wegner, B0000, Billings, MT  
J. Bladow, J0000, Loveland, CO

Reference A3000 memorandum of January 20, 1998, same subject, this memorandum amends the Accident Investigation Board by replacing Craig R. Oliver with Larry Romero. The Board members are as follows:

Gerald C. Wegner - Regional Manager  
Billings, Montana; Chairman

Patrick M. Doak - Field Engineer  
Huron, South Dakota

Troy Henry - Safety Specialist  
Loveland, Colorado

Larry Romero - Electrical Engineer  
Golden, Colorado

Douglas N. Harness - Legal Advisor  
Golden, Colorado



Michael S. Cowan  
Chief Program Officer

cc:  
M. Hacskeylo, Acting A0000  
L. Juarez, Acting A0200  
D. Harness, A0203  
J. Dodd, Acting A0500  
V. Ponce, A1000, (w/copy of Jan 20 memorandum)  
L. Roux, A1300, (w/copy of Jan 20 memorandum)  
L. Romero, A1300, (w/copy of Jan 20 memorandum)  
J. Slawson, A3000  
J. Harris, A3200.HU  
P. Doak, A3220.HU  
T. Dembrowski, A3700  
D. Olson, B5300.HU  
C. Olivier, B5314.HU  
T. Carlson, G0000, Phoenix, AZ  
M. Lowell, G8000, Phoenix, AZ  
B. Marsh, J0700, Loveland, CO  
T. Henry, J0710, Loveland, CO

United States Government

Department of Energy

Western Area Power Administration

# memorandum

DATE: JAN 30 1998

REPLY TO  
ATTN OF: A3000

SUBJECT: Accident Review Board--Casa Grande Substation Accident, January 20, 1998

TO: D. Vernon, Office of Security Evaluations, EH-21  
G. Wegner, B0000, Billings, MT  
J. Bladow, J0000, Loveland, CO

This memorandum establishes an Accident Investigation Board to investigate the subject accident. The following Western employees will serve as Chairperson and members until the review is closed.

Gerald C. Wegner - Regional Manager  
Billings, Montana; Chairman

Patrick M. Doak - Field Engineer  
Huron, South Dakota

Troy Henry - Safety Specialist  
Loveland, Colorado

Craig R. Olivier - Electrician  
Huron, South Dakota

Douglas N. Harness - Legal Advisor  
Golden, Colorado

The scope of the board's investigation will include, but is not limited to identifying all relevant facts; analyzing those facts to determine the direct, contributing, and root causes of the accident; developing conclusions; and determining the judgments of need that, when implemented, should prevent the recurrence of the accident. The investigation will specifically address the role of management systems as they may have contributed to the accident and the application of lessons learned from similar accidents within Western.

The team members may charge their time and expenses to work order number: CAG-- 0006C 00 30016.

The report shall be forwarded by memorandum which states the Board's recommendations, to me within 30 calendar days of this correspondence.

Please keep the Office of Safety and Security advised of your progress and solicit their assistance or the technical assistance of any others that you may need.



Michael S. Cowan  
Chief Program Officer



## APPENDIX B

---

- **Casa Grande Substation 12.47-kV Bus Structure Drawing**  
*(Showing location of workers at time of the accident)*
- **Casa Grande Substation Temporary Switching Diagram**  
*(Showing perimeter of safe working area)*

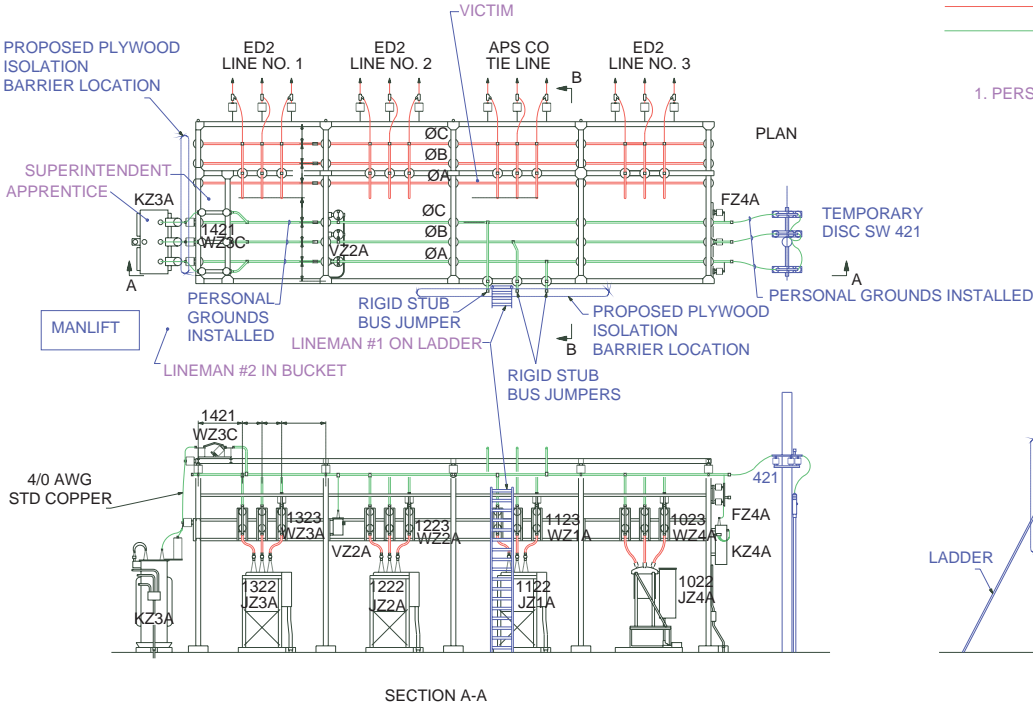
# **CASA GRANDE SUBSTATION 12.47KV BUS STRUCTURE**

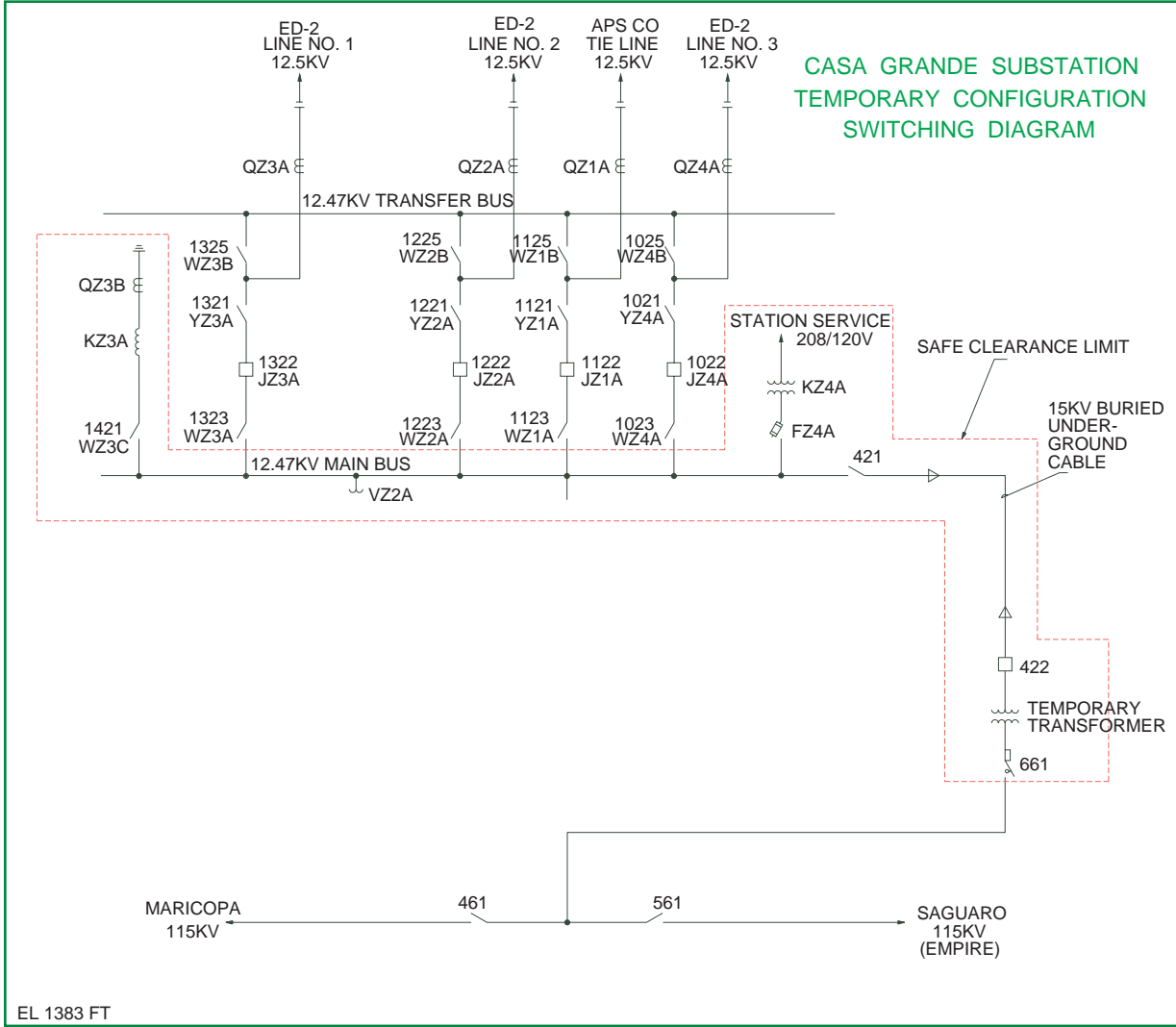
## **EXPLANATION**

- ENERGIZED TRANSFER BUS
- DE-ENERGIZED MAIN BUS

## **NOTE**

1. PERSONNEL LOCATIONS ARE APPROXIMATE.





## **APPENDIX C**

---

- **Clearance Procedure and Switching Program**
- **Special Work Permit**

SWITCHING PROCEDURE FORM  
PART ONE

SOP REF # 605

PROGRAM NO: \_\_\_\_\_

REQUEST BY: HARTILL FOR: CL TIME: 1300 DATE: 1/12/98  
SWITCH ST. TIME: 0800 DATE: / /  
WORK START TIME: 0900 DATE: 1/20/98 END- TIME: 1300 DATE: 1/20/98  
DAY: Tuesday  
STATION: CAG CASA GRANDE  
EQUIPMENT: 12.5-KV MAIN BUS TO INCLUDE STA. SER. (APS WILL CARRY LOAD).

BETWEEN: OPEN, LOCKED & TAGGED 115-KV MOI 661, DISCONNECT 1023, 1123, 1223,  
1323, 1421 AND REMOVED SECONDARY POT. FUSES VZ2A ON 12.5-KV BUS.

Vech. ##

|           |                   |          |             |             |
|-----------|-------------------|----------|-------------|-------------|
| NO. _____ | ISSUED TO _____   | BY _____ | TIME: _____ | DATE: _____ |
| NO. _____ | ISSUED TO _____   | BY _____ | TIME: _____ | DATE: _____ |
| NO. _____ | ISSUED TO _____   | BY _____ | TIME: _____ | DATE: _____ |
| NO. _____ | ISSUED TO _____   | BY _____ | TIME: _____ | DATE: _____ |
| NO. _____ | RELEASED BY _____ | TO _____ | TIME: _____ | DATE: _____ |
| NO. _____ | RELEASED BY _____ | TO _____ | TIME: _____ | DATE: _____ |
| NO. _____ | RELEASED BY _____ | TO _____ | TIME: _____ | DATE: _____ |
| NO. _____ | RELEASED BY _____ | TO _____ | TIME: _____ | DATE: _____ |

WORK TO BE DONE: INSTALL SAFETY BARRIER ON 12.5-KV BUS STR TO ALLOW CONST.  
OF YARD AND JUMPERS FROM DISC. 1421 TOWARDS BUS WILL BE REMOVED.

OTHERS NOTIFIED: COL- NOTES APS- EDVES ED2- Call

AUTHORIZED BY: CWM TIME: 1352 DATE: 1/12/98  
PREPARED BY: CWM TIME: 1352 DATE: 1/12/98

CHECKED BY: \_\_\_\_\_ TIME: \_\_\_\_\_ DATE: \_\_\_\_\_  
SWITCHING TO REMOVE EQUIPMENT FROM SERVICE: OK TO PROCEED

TIME: \_\_\_\_\_ DATE: \_\_\_\_\_ DISPATCHER \_\_\_\_\_ SWITCHMAN \_\_\_\_\_

SWITCHING TO RETURN EQUIPMENT TO SERVICE: OK TO PROCEED

TIME: \_\_\_\_\_ DATE: \_\_\_\_\_ DISPATCHER \_\_\_\_\_ SWITCHMAN \_\_\_\_\_

COMMENTS:

SWP2

PHOENIX AREA OFFICE

CAG

SWITCHING PROCEDURE FORM

PROGRAM NO: 98-065

EQUIPMENT: 12.5-KV MAIN BUS TO INCLUDE STA. SER. (APS WILL CARRY LOAD).

| #  | WHO | WHAT      | PART TWO - PLACE ACTION<br>EQUIPMENT AND DESCRIPTION  | TAG #       | TIME | SWITCHMAN        |
|----|-----|-----------|---|-------------|------|------------------|
| 1  | DSP | NOTIFY    | APS, ED2. OF SWITCHING.   |             |      | DORN             |
| 2  | CAG | CK PLACE  | REG. ON MANUAL AND MATCH DOE KV TO APS<br>TIE KV.   |             |      |                  |
| 3  | DSP | CLOSE     | AT CAG, (AT APS REQUEST) PCB 1122,<br>PARALLELING APS & WESTERN.                                | 0841        |      |                  |
| 4  | CAG | CK CLOSED | PCB 1122 AT PCB.  | 0843        |      | ROETHLE<br>BOYER |
| 5  | CAG | CLOSE     | DISCONNECT 1125.  | 0844        |      |                  |
| 6  | CAG | CK CLOSED | PCB 1022 AT PCB.  | 0844        |      |                  |
| 7  | CAG | CLOSE     | DISCONNECT 1025.  | 0845        |      |                  |
| 8  | CAG | CK CLOSED | PCB 1222 AT PCB.  | 0845        |      |                  |
| 9  | CAG | CK CLOSED | DISCONNECT 1225.  | 0845        |      |                  |
| 10 | CAG | CK CLOSED | PCB 1322 AT PCB.  | 0846        |      |                  |
| 11 | CAG | CLOSE     | DISCONNECT 1325.  | 0847        |      |                  |
| 12 | DSP | OPEN      | AT CAG, PCB 1322.   | 0848        |      | DORN             |
| 13 | DSP | OPEN      | AT CAG, PCB 1222.   | 0849        |      |                  |
| 14 | DSP | OPEN      | AT CAG, PCB 1022.   | 0849        |      |                  |
| 15 | DSP | OPEN      | AT CAG, PCB 1122, (BREAKING PARALLEL).<br>(APS CARRYING ED2 LOAD VIA TRANSFER<br>BUS).          | 0850        |      |                  |
| 16 | CAG | READ      | THE FOLLOWING REVENUE METERS: CG-236;<br>CG-237; CG-212. READ REVENUE METER CG<br>202 (APS IN). | 0853        |      | ROETHLE<br>BOYER |
| 17 | DSP | OPEN      | AT CAG, PCB 422, DE-ENERGIZING STA.<br>SER. AND MAIN 12.5-KV BUS.                               | 0854        |      | DORN             |
| 18 | DSP | OPEN      | AT CAG, MOI 661, DE-ENERGIZING TEMP<br>XFMR BANK.   | L/T 0854    |      |                  |
| 19 | CAG | PLACE     | 43CS SWITCH MOI 661 TO LOCAL.   | TAG 15 0857 |      | ROETHLE<br>BOYER |
| 20 | CAG | CK OPEN   | MOI 661 AT MOI AND DISABLE MOTOR<br>OPERATING MECHANISM.  | L/T 7 0901  |      |                  |
| 21 | CAG | CK OPEN   | PCB 1322 AT PCB.  | 0902        |      |                  |
| 22 | CAG | OPEN      | DISCONNECT 1323.  | TAG 2 0903  |      |                  |

Revised: 12/10/97

01/13/98 08:35 WAPA DISPATCH → COOLIDGE SUB

NO. 900 P004/006

SWP2

PHOENIX AREA OFFICE

CAG

SWITCHING PROCEDURE FORM

PROGRAM NO: 98

EQUIPMENT: 12.5-KV MAIN BUS TO INCLUDE STA. SER. (APS WILL CARRY LOAD).

| #  | WHO | WHAT    | PART TWO - PLACE ACTION<br>EQUIPMENT AND DESCRIPTION       | TAG #  | TIME | SWITCHMAN |
|----|-----|---------|--|--------|------|-----------|
| 23 | CAG | CK OPEN | PCB 1222 AT PCB.   |        | 0904 | ROETHLE   |
| 24 | CAG | OPEN    | DISCONNECT 1223.   | TAG 12 | 0904 | BOYER     |
| 25 | CAG | CK OPEN | PCB 1122 AT PCB.   |        | 0905 |           |
| 26 | CAG | OPEN    | DISCONNECT 1123.   | TAG 11 | 0906 |           |
| 27 | CAG | CK OPEN | PCB 1022 AT PCB.   |        | 0906 |           |
| 28 | CAG | OPEN    | DISCONNECT 1023.   | TAG 10 | 0907 |           |
| 29 | CAG | REMOVE  | 12.5-KV SECONDARY POTENTIAL FUSES TO<br>MAIN BUS "VZ2A".   | TAG 9  | 0909 |           |
| 30 | CAG | CK OPEN | GROUND TRANSFORMER DISCONNECT 1421.<br>(NO LONGER IN USE). | L/E    |      |           |

Revised: 12/10/97

SWP3

## PHOENIX AREA OFFICE

CAG

## SWITCHING PROCEDURE FORM

PROGRAM NO: 98-065

EQUIPMENT: 12.5-KV MAIN BUS TO INCLUDE STA. SER. (APS WILL CARRY LOAD).

| #  | WHO | WHAT      | PART THREE - REMOVE ACTION<br>EQUIPMENT AND DESCRIPTION                        | TAG # | TIME          | SWITCHMAN        |
|----|-----|-----------|--|-------|---------------|------------------|
| 1  | DSP | NOTIFY    | APS, ED2, OF SWITCHING.  |       |               |                  |
| 2  | CAG | CK REMOVE | JUMPERS FROM DISCONNECT 1421 TOWARDS<br>MAIN BUS. (GRD BANK NO LONGER IN USE). | T/R   |               | ROETHLE<br>BOYER |
| 3  | CAG | REPLACE   | FUSES "VZ2A" 12.5-KV MAIN BUS SECONDARY<br>POTENTIAL.                          | T/R   | 9 1314        |                  |
| 4  | CAG | CK CLOSED | STATION SERVICE FUSED DISCONNECT F24A.   |       | 1316          |                  |
| 5  | CAG | CK OPEN   | PCB 1022 AT PCB.   |       | 1316          |                  |
| 6  | CAG | CLOSE     | DISCONNECT 1023.   | T/R   | 10 1317       |                  |
| 7  | CAG | CK OPEN   | PCB 1122 AT PCB.   |       | 1318          |                  |
| 8  | CAG | CLOSE     | DISCONNECT 1123.   | T/R   | 11 1319       |                  |
| 9  | CAG | CK OPEN   | PCB 1222 AT PCB.   |       | 1319          |                  |
| 10 | CAG | CLOSE     | DISCONNECT 1223.   | T/R   | 12 1320       |                  |
| 11 | CAG | CK OPEN   | PCB 1322 AT PCB.   |       | 1320          |                  |
| 12 | CAG | CLOSE     | DISCONNECT 1323.   | T/R   | 2 1321        |                  |
| 13 | CAG | CK OPEN   | PCB 422 AT PCB.  |       | 1321          |                  |
| 14 | CAG | CK CLOSED | DISCONNECT 421.  |       | 1322          |                  |
| 15 | CAG | CK OPEN   | MOI 661 AT MOI AND ENABLE MOTOR<br>OPERATING MECHANISM.                        | T/R   | 7 1323        |                  |
| 16 | CAG | PLACE     | 43CS SWITCH MOI 661 TO SUPERVISORY<br>POSITION.                                | T/R   | 15 1325       | ✓                |
| 17 | DSP | CLOSE     | AT CAG, MOI 661, ENERGIZING TEMP XFMR<br>BANK.                                 | T/R   | 1409<br>1359  | DORN             |
| 18 | CAG | CK CLOSED | MOI 661 AT MOI.  |       | 1402          | ROETHLE<br>BOYER |
| 19 | CAG | CLOSE     | PCB 422, ENERGIZING 12.5-KV MAIN BUS<br>AND STA. SER.                          |       | MANUALLY 1418 |                  |
| 20 | CAG | MATCH     | XFMR TAP BASED ON MAR 115-KV BUS<br>VOLTAGE.                                   |       |               |                  |
| 21 | DSP | CLOSE     | AT CAG, PCB 1122, PARALLELING WITH APS.  |       | 1424          | DORN             |
| 22 | DSP | CLOSE     | AT CAG, PCB 1022.  |       | 1425          |                  |
| 23 | DSP | CLOSE     | AT CAG, PCB 1222.  |       | 1425          |                  |

Revised: 12/10/97

GENERAL CK OPEN MOI 661 - 1410  
 OPENED DISC 421 - 1412  
 CLOSED " " 1422



SWP3

## PHOENIX AREA OFFICE

CAG

## SWITCHING PROCEDURE FORM

PROGRAM NO: \_\_\_\_\_

EQUIPMENT: 12.5-KV MAIN BUS TO INCLUDE STA. SER. (APS WILL CARRY LOAD).

| #  | WHO | WHAT      | PART THREE - REMOVE ACTION<br>EQUIPMENT AND DESCRIPTION      | TAG # | TIME | SWITCHMAN        |
|----|-----|-----------|--|-------|------|------------------|
| 24 | DSP | CLOSE     | AT CAG, PCB 1322.  | 1425  |      | DORN             |
| 25 | CAG | CK CLOSED | PCB 1322 AT PCB.   | 1436  |      | ROETHLE<br>BOYER |
| 26 | CAG | OPEN      | DISCONNECT 1325.   | 1437  |      |                  |
| 27 | CAG | CK CLOSED | PCB 1222 AT PCB.   | 1437  |      |                  |
| 28 | CAG | CK CLOSED | DISCONNECT 1225. (LEAVE CLOSED,<br>ENERGIZING TRANSFER BUS). | 1437  |      |                  |
| 29 | CAG | CK CLOSED | PCB 1022 AT PCB.   | 1438  |      |                  |
| 30 | CAG | OPEN      | DISCONNECT 1025.   | 1438  |      |                  |
| 31 | CAG | CK CLOSED | PCB 1122 AT PCB.   | 1438  |      |                  |
| 32 | CAG | OPEN      | DISCONNECT 1125.   | 1439  |      |                  |
| 33 | DSP | OPEN      | AT CAG, PCB 1122, (BREAKING PARALLEL).                       | 1442  |      | DORN             |
| 34 | CAG | READ      | REVENUE METERS CG-236; CG-237; CG-212.<br>& CG 202 (APS IN). | 1443  |      | ROETHLE          |
| 35 | DSP | NOTIFY    | APS _____ ED2 _____<br>SWITCHING COMPLETED.                  |       |      |                  |

Revised: 12/10/97

UNITED STATES DEPARTMENT OF ENERGY  
WESTERN AREA POWER ADMINISTRATION

**SPECIAL WORK PERMIT**

NUMBER C98-065

SOLICITATION NO. \_\_\_\_\_

A POWER SYSTEM (CLEARANCE) (~~HOT LINE ORDER~~) HAS BEEN ISSUED ON THE FOLLOWING FACILITY,  
(MARK ONE OUT)

Casa Grande Main Bus to Include sta. Ser.

TO PERMIT WORK BY CONTRACTOR FORCES, THE UNDERSIGNED HAVE DISCUSSED THE WORK TO BE DONE, REVIEWED THE DETAILS OF THE ABOVE LISTED PROTECTIVE ACTION FOR ADEQUACY, AND DEFINED THE LIMITS AND CONDITIONS OF THE SAFE WORKING AREA. THE LIMITS OF THE SAFE WORKING AREA ARE AS FOLLOWS:

Open locked & tagged 115KV MOT 661

Open locked and tagged <sup>12.5KV</sup> Disc. Ser. #1023, #1123,  
#1223, #1323, #1421 and Removed Secondary  
Potential Fuses V22A on 12.5KV Bus

**DOCUMENT LOCATION OF GROUND  
LEADS ON SPECIAL WORK PERMIT!**

Issuing Dispatcher: Doran

Releasing Dispatcher: Doran

Release Time: 1307

When work complete, visually  
verify all ground leads removed  
(including any that slipped  
by the documentation process)

NOTE: Draw sketches and/or single line diagrams on reverse side showing safe working limits and hazards if applicable.

☒ CLEARANCE NO. 98-065

☐ HOT LINE ORDER DATE 1-20-97 TIME 0917

Gary L. Trufford  
(Signature)  
AGENCY EMPLOYEE HOLDING ACTION

This Work Permit issued at the worksite Date 1-20-97 Time 0920  
and the contractor is authorized to proceed with the work in the area designated above.

Douglas K. Kline  
(Signature)  
CONTRACTOR'S AUTHORIZED REPRESENTATIVE  
AT THE WORKSITE

Gary L. Trufford  
(Signature)  
AGENCY REPRESENTATIVE IN CHARGE  
AT THE WORKSITE

**RELEASE OF SPECIAL WORK PERMIT**

I HEREBY CERTIFY THAT ALL PROTECTIVE GROUNDS AND BARRIERS HAVE BEEN REMOVED  
AND THAT ALL PERSONNEL ARE CLEAR OF THE AREA COVERED BY THIS WORK PERMIT.

CONTRACTOR'S AUTHORIZED REPRESENTATIVE (SIGNATURE)

DATE

TIME

Douglas K. Kline

1-20-98

13:05 PM

|                   |  |
|-------------------|--|
| O&M COPY          |  |
| CONSTRUCTION COPY |  |
| CONTRACTOR COPY   |  |
| OTHER             |  |

# DOCUMENTATION OF GROUND LEAD LOCATIONS

| Location of Grounds | Date/Time Installed | Sup't/WAPA Initials | Date/Time Removed | Sup't/WAPA Initials |
|---------------------|---------------------|---------------------|-------------------|---------------------|
|                     |                     |                     |                   |                     |
|                     |                     |                     |                   |                     |
|                     |                     |                     |                   |                     |
|                     |                     |                     |                   |                     |
|                     |                     |                     |                   |                     |
|                     |                     |                     |                   |                     |
|                     |                     |                     |                   |                     |

SKETCH LOCATION OF GROUNDS (if needed)



